

CLAIMS

What is claimed is:

1. (Currently amended) An electroplating bath for depositing a zinc-nickel ternary or higher alloy, comprising:
 - a) zinc ions;
 - b) nickel ions; and
 - c) from about 0.01 g/dm³ to about 10 g/dm³ of one or more ionic species selected from ions of Te⁺⁴, Bi⁺³ and Sb⁺³, with the proviso that when the ionic species comprises Te⁺⁴, the bath further comprises one or more additional ionic species selected from ions of Bi⁺³, Sb⁺³, Ag⁺¹, Cd⁺², Co⁺², Cr⁺³, Cu⁺², Fe⁺², In⁺³, Mn⁺², Mo⁺⁶, P⁺³, Sn⁺² and W⁺⁶; and
 - d) one or more non-ionogenic surface active polyoxyalkylene compound.
2. (Original) The bath of claim 1 wherein when the ionic species comprises one or more of Bi⁺³ or Sb⁺³, the bath further comprises one or more additional ionic species selected from ions of Ag⁺¹, Cd⁺², Co⁺², Cr⁺³, Cu⁺², Fe⁺², In⁺³, Mn⁺², Mo⁺⁶, P⁺³, Sn⁺² and W⁺⁶.
3. (Currently amended) The bath of claim 1 wherein the zinc ion and the nickel ion are present in the bath at concentrations sufficient to deposit ~~a zinc-nickel~~ the alloy comprising a nickel content from about 3 wt% to about 25 wt% of the alloy.
4. (Currently amended) The bath of claim 1 wherein the zinc ion and the nickel ion are present in the bath at concentrations sufficient to deposit ~~a zinc-nickel~~ the alloy comprising a nickel content from about 8 wt% to about 22 wt% of the alloy.
5. (Currently amended) The bath of claim 1 ~~further comprising one or more non-ionogenic, surface active polyoxyalkylene compound~~ wherein the concentration of Bi⁺³ is in the range from 0.2 to 2 g/dm³.

6. (Currently amended) The bath of ~~claim 5~~ claim 1 wherein the one or more non-ionogenic surface active polyoxyalkylene compound comprises:

(i) at least one ~~or more~~ compound having a formula:



or



or



wherein R^1 is an aryl or alkyl group containing up to about 24 carbon atoms, R^2 is an alkyl group containing from 1 to about 4 carbon atoms, n is 2 or 3, and x is an integer between 2 and about 100;

(ii) at least one ~~or more~~ compound having a formula:



or



wherein R^3 = a C_1 - C_{18} branched or unbranched alkyl, alkylene or alkynyl group, or phenyl- $O-[R^5-O-]_m-CH_2-$, in which $m = 0-100$, n is 2 or 3 and R^5 is a C_1 - C_4 branched or unbranched alkylene; R^4 = C_1 - C_4 branched or unbranched alkylene; $X = H$, $-SO_2Z$, $-SO_3Z$, $-SO_4Z$, $-PO_3Z_2$, $-PO_4Z_2$ (wherein Z independently may be H , an alkali metal ion, or Z_2 may be an alkaline earth metal ion) $-NH_2$, $-Cl$ or $-Br$; Y is an aliphatic polyhydroxy group, an amine group, a polyamine group or a mercaptan group, and a is equal to or less than the number of active hydrogens in OH , $-NH$, NH_2 or $-SH$ groups on the Y component; or

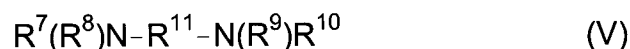
(iii) a mixture of two or more of (i) and/or (ii).

7. (Original) The bath of claim 1 wherein the bath comprises an acidic pH.

8. (Original) The bath of claim 1 wherein the bath comprises an alkaline pH and further comprises a complexing agent.

9. (Currently amended) The bath of claim 8 ~~further comprising one or more non-ionogenic, surface active polyoxyalkylene compound~~ 1 wherein the concentration of Sb^{+3} is in the range from 0.1 to 3 g/dm³.

10. (Original) The bath of claim 8 wherein the complexing agent comprises an aliphatic amine, a polymer of an aliphatic amine, a compound represented by the formula



wherein R^7 , R^8 , R^9 and R^{10} are each independently alkyl or hydroxyalkyl groups provided that one or more of R^7 - R^{10} is a hydroxy alkyl group, and R^{11} is a hydrocarbylene group containing up to about 10 carbon atoms, or a mixture of two or more thereof.

11-42. (Cancelled)

43. (Currently amended) An electroplating bath for depositing a zinc-nickel ternary or higher alloy, comprising:

- a) zinc ions;
- b) nickel ions; ~~and~~
- c) from about 0.01 g/dm³ to about 10 g/dm³ of one or more ionic species selected from ions of Te^{+4} , Bi^{+3} and Sb^{+3} , and
one or more non-ionogenic surface active polyoxyalkylene compound,
 with the proviso that when the ionic species comprises Te^{+4} , the bath is free of a mixture of brighteners comprising both (i) reaction product of epihalohydrin with an alkylene amine ~~amines such as ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; and higher alkylene polyamines,~~ and (ii) aromatic aldehydes.

44. (Original) The bath of claim 43 wherein the bath further comprises one or more additional ionic species selected from ions of Ag^{+1} , Cd^{+2} , Co^{+2} , Cr^{+3} , Cu^{+2} , Fe^{+2} , In^{+3} , Mn^{+2} , Mo^{+6} , P^{+3} , Sn^{+2} and W^{+6} .

45. (New) The bath of claim 10 wherein the alkylene amine of (i) comprises ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; or a higher alkylene polyamine.

46. (New) The bath of claim 43 wherein the zinc ion and the nickel ion are present in the bath at concentrations sufficient to deposit the alloy comprising a nickel content from about 3 wt% to about 25 wt% of the alloy.

47. (New) The bath of claim 43 wherein the zinc ion and the nickel ion are present in the bath at concentrations sufficient to deposit the alloy comprising a nickel content from about 8 wt% to about 22 wt% of the alloy.

48. (New) The bath of claim 43 wherein the concentration of Bi^{+3} is in the range from 0.2 to 2 g/dm³.

49. (New) The bath of claim 43 wherein the concentration of Sb^{+3} is in the range from 0.1 to 3 g/dm³.

50. (New) The bath of claim 43 wherein the one or more non-ionogenic surface active polyoxyalkylene compound comprises:

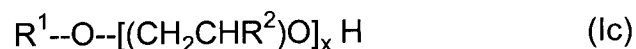
(i) at least one compound having a formula:



or

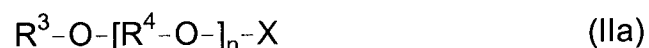


or



wherein R^1 is an aryl or alkyl group containing up to about 24 carbon atoms, R^2 is an alkyl group containing from 1 to about 4 carbon atoms, n is 2 or 3, and x is an integer between 2 and about 100;

(ii) at least one compound having a formula:



or



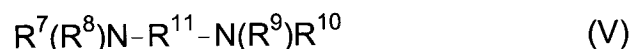
wherein R^3 = a C_1 - C_{18} branched or unbranched alkyl, alkylene or alkynyl group, or phenyl- $O-[R^5-O-]_m-CH_2-$, in which $m = 0$ -100, n is 2 or 3 and R^5 is a C_1 - C_4 branched or unbranched alkylene; R^4 = C_1 - C_4 branched or unbranched alkylene; $X = H$, $-SO_2Z$, $-SO_3Z$, $-SO_4Z$, $-PO_3Z_2$, $-PO_4Z_2$ (wherein Z independently may be H , an alkali metal ion, or Z_2 may be an alkaline earth metal ion) $-NH_2$, $-Cl$ or $-Br$; Y is an aliphatic polyhydroxy group, an amine group, a polyamine group or a mercaptan group, and a is equal to or less than the number of active hydrogens in OH , $-NH$, NH_2 or $-SH$ groups on the Y component; or

(iii) a mixture of two or more of (i) and/or (ii).

51. (New) The bath of claim 43 wherein the bath comprises an acidic pH.

52. (New) The bath of claim 43 wherein the bath comprises an alkaline pH and further comprises a complexing agent.

53. (New) The bath of claim 52 wherein the complexing agent comprises an aliphatic amine, a polymer of an aliphatic amine, a compound represented by the formula



wherein R^7 , R^8 , R^9 and R^{10} are each independently alkyl or hydroxyalkyl groups provided that one or more of R^7 - R^{10} is a hydroxy alkyl group, and R^{11} is a hydrocarbylene group containing up to about 10 carbon atoms, or a mixture of two or more thereof.

54. (New) The bath of claim 53 wherein the alkylene amine of (i) comprises ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; or a higher alkylene polyamine.

55. (New) An electroplating bath for depositing a zinc-nickel quaternary or higher alloy, comprising:

- a) zinc ions;
- b) nickel ions;
- c) one or more ionic species selected from ions of Te^{+4} , Bi^{+3} and Sb^{+3} ;
- d) one or more ionic species selected from ions of Ag^{+1} , Cd^{+2} , Co^{+2} , Cr^{+3} , Cu^{+2} , Fe^{+2} , In^{+3} , Mn^{+2} , Mo^{+6} , P^{+3} , Sn^{+2} and W^{+6} ; and
- e) one or more non-ionogenic surface active polyoxyalkylene compound.

56. (New) The bath of claim 55 wherein the zinc ion and the nickel ion are present in the bath at concentrations sufficient to deposit the alloy comprising a nickel content from about 3 wt% to about 25 wt% of the alloy.

57. (New) The bath of claim 55 wherein the zinc ion and the nickel ion are present in the bath at concentrations sufficient to deposit the alloy comprising a nickel content from about 8 wt% to about 22 wt% of the alloy.

58. (New) The bath of claim 55 wherein the concentration of Bi^{+3} is in the range from 0.2 to 2 g/dm³.

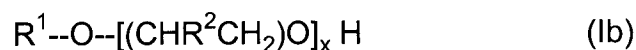
59. (New) The bath of claim 55 wherein the concentration of Sb^{+3} is in the range from 0.1 to 3 g/dm³.

60. (New) The bath of claim 55 wherein the one or more non-ionogenic surface active polyoxyalkylene compound comprises:

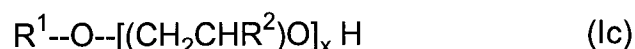
(i) at least one compound having a formula:



or



or



wherein R^1 is an aryl or alkyl group containing up to about 24 carbon atoms, R^2 is an alkyl group containing from 1 to about 4 carbon atoms, n is 2 or 3, and x is an integer between 2 and about 100;

(ii) at least one compound having a formula:



or



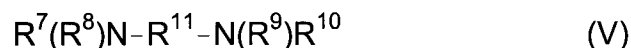
wherein R^3 = a C_1 - C_{18} branched or unbranched alkyl, alkylene or alkynyl group, or phenyl- $O-[R^5-O-]_m-CH_2-$, in which $m = 0-100$, n is 2 or 3 and R^5 is a C_1 - C_4 branched or unbranched alkylene; R^4 = C_1 - C_4 branched or unbranched alkylene; $X = H$, $-SO_2Z$, $-SO_3Z$, $-SO_4Z$, $-PO_3Z_2$, $-PO_4Z_2$ (wherein Z independently may be H , an alkali metal ion, or Z_2 may be an alkaline earth metal ion) $-NH_2$, $-Cl$ or $-Br$; Y is an aliphatic polyhydroxy group, an amine group, a polyamine group or a mercaptan group, and a is equal to or less than the number of active hydrogens in OH , $-NH$, NH_2 or $-SH$ groups on the Y component; or

(iii) a mixture of two or more of (i) and/or (ii).

61. (New) The bath of claim 55 wherein the bath comprises an acidic pH.

62. (New) The bath of claim 55 wherein the bath comprises an alkaline pH and further comprises a complexing agent.

63. (New) The bath of claim 62 wherein the complexing agent comprises an aliphatic amine, a polymer of an aliphatic amine, a compound represented by the formula



wherein R^7 , R^8 , R^9 and R^{10} are each independently alkyl or hydroxyalkyl groups provided that one or more of R^7 - R^{10} is a hydroxy alkyl group, and R^{11} is a hydrocarbylene group containing up to about 10 carbon atoms, or a mixture of two or more thereof.

64. (New) The bath of claim 63 wherein the alkylene amine of (i) comprises ethylenediamine or its methyl-substituted derivatives; propylenediamine or its methyl-substituted derivatives; diethylenetriamine or its methyl-substituted derivatives; or a higher alkylene polyamine.